CAIT
Center for Advanced Infrastructure & Transportation
Rutgers, The State University of New Jersey

QUARTERLY PROGRESS REPORT

Project Title:	Bridge Deck Cracking and Composite Action Analysis
RFP NUMBER:	NJDOT RESEARCH PROJECT MANAGER: Anthony Chmiel
TASK ORDER NUMBER: TO 190 / RU Acct 4-22705	PRINCIPAL INVESTIGATOR: Dr. Hani Nassif
Project Starting Date: 06/01/2006 **Original** Project Ending Date: 5/31/2008 **Modified Completion Date:**	Period Covered: 4th Quarter 2006

Task #	Task	% of Total	Fixed Budget	% of Task this quarter	Cost this quarter	% of Task to date	Total cost to date
1	Mobilization	4.82%	$ 10,000	0.0%	$ -	100.0%	$ 10,000
2	Literature Search	9.64%	$ 20,000	25.0%	$ 5,000	75.0%	$ 15,000
3	Composite Action Analysis	19.27%	$ 40,000	10.0%	$ 4,000	30.0%	$ 12,000
4	3D FEA - Composite Action	19.27%	$ 40,000	10.0%	$ 4,000	15.0%	$ 6,000
5	3D FEA -NJDOT Deflection Requirements	12.04%	$ 25,000	10.0%	$ 2,500	20.0%	$ 5,000
6	3D FEA - NJDOT Class A Concrete Requirements	12.04%	$ 25,000	10.0%	$ 2,500	20.0%	$ 5,000
7		0.00%	$ -	0.0%	$ -	0.0%	$ -
8		0.00%	$ -	0.0%	$ -	0.0%	$ -
9		0.00%	$ -	0.0%	$ -	0.0%	$ -
10		0.00%	$ -	0.0%	$ -	0.0%	$ -
11		0.00%	$ -	0.0%	$ -	0.0%	$ -
12		0.00%	$ -	0.0%	$ -	0.0%	$ -
13		0.00%	$ -	0.0%	$ -	0.0%	$ -
14		0.00%	$ -	0.0%	$ -	0.0%	$ -
15		0.00%	$ -	0.0%	$ -	0.0%	$ -
16		0.00%	$ -	0.0%	$ -	0.0%	$ -
17		0.00%	$ -	0.0%	$ -	0.0%	$ -
18		0.00%	$ -	0.0%	$ -	0.0%	$ -
19		0.00%	$ -	0.0%	$ -	0.0%	$ -
20	Final Report and Quarterly Reporting	22.92%	$ 45,574	10.0%	$ 4,557	20.0%	$ 9,115
	TOTAL	100.0%	$ 205,574		$ 22,557		$ 62,115

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Green text is updated ever quarter

Black text is automatically updated or static

Project Objectives:

The main objective of this study is to evaluate the cracking behavior of concrete bridge decks and explore the cause of the cracking problem related to design procedures. Using 3D Finite Element Method (FEM) as an analysis tool, the proposed project will identify the design procedures and

parameters that most directly relate to the severity of cracking in bridge decks. Both AASHTO Standard Specification (LFD) and AASHTO LRFD Bridge Design Specification (LRFD) will be evaluated; especially regarding design provisions related to the shear studs and deflection limits. The identification process will be implemented in five tasks: (1) literature search; (2) evaluation of LFD and LRFD design procedures for composite action; (3) development of a detailed FE model that incorporates field measurements, environmental conditions (such as temperature and differential expansion between steel and concrete), and shrinkage behavior of concrete material based on actual data or laboratory testing; (4) deflection requirements; and (5) concrete compressive strength. The end result will be to provide a methodology that will enable New Jersey Department of Transportation (NJDOT) to successfully select the appropriate design modifications and construction guidelines that minimize the cracking potential of decks for girder bridges.

Project Abstract:

According to the American Society of Civil Engineers (ASCE) Report Card, the US infrastructure received a grade point average of "D" (i.e., poor rating) in 2005. Moreover, the National Bridge Inventory (NBI) (Federal Highway Administration, 2004) stated that of more than 594,470 bridges in the United States, about 150,981 (25.4%) are structurally deficient or obsolete. Major decisions must be made to allocate the limited funds available for repair, rehabilitation, and replacement. An investment of at least $1.6 trillion is needed in the next five years to alleviate the problems. Accordingly, many State departments of transportation expend significant effort and resources on the construction of durable concrete bridge decks. Existing data and current research indicate that specific modifications to construction procedures, materials, and design details can significantly reduce the degree of cracking in bridge decks and thus reduce exposure of reinforcing steel to the corrosive effects of deicing chemicals as well as decrease freeze-thaw damage. A great deal is known about the factors that affect cracking in bridge decks, and what is needed is to implement this knowledge and monitor deck performance. However, there is need to fully understand the effect of various design parameters that are related to bridge cracking behavior.

To study the cracking behavior of bridge decks, a detailed 3D FE model will be developed. A general-purpose finite element program, ABAQUS, will be utilized to derive the model. ABAQUS includes a variety of routines that allow for defining specific material models and provisions, such as concrete cracking and tension stiffening models, reinforcing steel rebar, boundary conditions, bond behavior (e.g., shear studs) and interaction between the reinforcing steel bars and concrete, and its mechanical properties. In addition, early-age cracking is often associated with material properties of concrete, especially concrete mixes that have high early-age strength development or high shrinkage performance. Furthermore, the FEM results will be validated using field results from various sources including those developed at Rutgers University and relate the possible cause of cracking on the bridge decks (e.g., thermo-stresses, heat of hydration, shrinkage, and live load). Once the model is validated and calibrated using field and laboratory measurements, the parametric study on modifying the design procedure can be carried out. The results of this research will add to that knowledge and will lead to reduction in bridge deck cracking, an improvement in durability, and an increase in the useful life of bridges.

1. Progress this quarter by task:

Task 1—Literature Search:

- Research team continues to collect more references including papers, reports, and case studies related to bridge deck cracking.

Task 2—Composite Action Analysis

- Composite action between deck slab and girder was modeled in the Finite element analysis program. The model was used to evaluate the design provisions in the AASHTO LRFD and Standard specifications for shear studs with regard to their effect on cracking performance.

Task 3—Perform Analysis using a 3D FE Model Considering LRFD Composite Action Requirements

- Used the finite element model developed for various types bridges in the analysis of concrete bridge decks and study the effect of different parameters such as concrete material properties, rebar mesh layers, and bond, on the cracking of concrete.
- The FE model is also being used to study the effect of temperature and other environmental conditions.

Task 4—Perform 3D FEA for Typical Bridges with NJDOT Deflection Requirements

- Collected data and used results from various field tests in validating the FE model. The field tests included strain and deflection measurements.

Task 5—Perform 3D FEA for Typical Bridges with NJDOT Class A Concrete

- Modeled the bridge deck using various rebar configurations to check cracking of concrete deck. The rebar configurations included for example placing the longitudinal rebars on top of transverse rebars.

2. Proposed activities for next quarter by task:

Task 1—Literature Search:

- Research team will continue to collect references related to bridge deck cracking.

Task 2—Composite Action Analysis

- Results from tests performed on composite beams with a reduced number of shear studs relative to code requirement will be used to compare restrained shrinkage behavior and their effect on cracking at early age.

Task 3—Perform Analysis using a 3D FE Model Considering LRFD Composite Action Requirements

- Continue to improve on the 3D FE model.

Task 4—Perform 3D FEA for Typical Bridges with NJDOT Deflection Requirements

- Review deflection criteria from various sources.

Task 5—Perform 3D FEA for Typical Bridges with NJDOT Class A Concrete

- Compare the results of various FE bridge models when using different mechanical properties of concrete mixes such as compressive strength, tensile, elastic modulus.

3. List of deliverables provided in this quarter by task (product date):

- Literature review
- Finite element model for various types of bridges.
- Analysis of bridge decks with various rebar configurations.
- Comparison of results from field tests and finite element model.

4. Progress on Implementation and Training Activities:

N/A

5. Problems/Proposed Solutions:

- Request several bridges designed using LRFD and LFD from NJDOT so that we can model and try to vary various parameters.
- Project funds as allocated by the research Bureau are limited to achieve all the tasks as was initially proposed. There is a need to plan pool fund for second year.

Total Project Budget	$205,574
Modified Contract Amount:	
Total Project Expenditure to date	$62,115
% of Total Project Budget Expended	30.2%

NJDOT Research Project Manager Concurrence: _____ Date: _____